FURTHER STUDIES ON ZINC SULFATE IN PEACH SPRAYS

WITH LIMITED TESTS IN APPLE SPRAYS

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UNIVERSITY OF ILLINOIS
AGRICULTURAL EXPERIMENT STATION

Bulletin 424

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Urbana, Illinois July, 1

Publications in the Bulletin series report the results of investigations made by or sponsored by the Experiment Station

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THE INTRODUCTION and recommendation of zinc sulfate as an ingredient in peach sprays by Roberts and Pierce[12*] in 1929 was one of the most important recent contributions to the peach-growing industry. Until this chemical was added to peach spray mixtures, acid lead arsenate and hydrated lime, with or without sulfur, were the standard materials for peach sprays. Acid lead arsenate, however, often caused severe injury to trees and fruit, altho the seriousness of the injury had not been really appreciated until the work of Haensler and Martin[4*] was published in 1925. Zinc sulfate in peach sprays serves to reduce this injury.

When zinc sulfate was first recommended as an ingredient for peach sprays, its value in reducing spray injury was not fully realized. It was considered primarily a bactericide, fungicide, and plant stimulant. Contributions to a better understanding of the value of zinc sulfate in spray combinations have been made by Roberts *et al*,[12-20*] Poole,[10, 11*] Anderson,[2*] Anderson and Thornberry,[3*] Hurt,[5, 6*] Adams,[1*] Rudolph,[21*] Kadow,[7*] and Kadow and Anderson.[8, 9*] It now appears certain that the "corrective effect" of zinc sulfate on lead arsenate - lime injury is the principal reason for including it in peach sprays. In some sections of the United States, and in certain other parts of the world, zinc has proved very satisfactory as a remedy for some physiological diseases, none of which have been identified as yet in this state. Apparently Illinois soils have sufficient available zinc to permit proper plant development. Consequently in this state the only justification for commercial applications of zinc sulfate in peach sprays is to reduce the amount of lead arsenate injury.

As soon as it became apparent that zinc sulfate was of considerable value in reducing lead arsenate - lime injury to the peach, growers

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The authors wish to acknowledge the advice given by W. A. Ruth, Chief in Pomological Physiology, on certain chemical aspects of this study, and the help of W. P. Flint, Chief Entomologist, M. D. Farrar, Research Entomologist, and S. C. Chandler, Field Entomologist, of the Illinois State Natural History Survey, on entomological phases of the problem.

*These numbers refer to literature citations on page 140.

began using zinc in their sprays in varying amounts, usually at the rate of 8-8-100, as originally recommended. In the meantime the authors of the present bulletin began experiments to determine more exactly the amount of zinc necessary to prevent spray injury. The results of these studies, together with data on limited tests of zinc sulfate as an ingredient in apple sprays, are presented in this bulletin.

LABORATORY STUDIES

The chemical aspects of this problem were reviewed in detail by the present investigators in a recent discussion[8*] of the relation of $ZnSO_4 \cdot 7H_2O$ to spray injury, and therefore will not be reconsidered in this paper. Among the chemical relations there reviewed, the important facts to remember in connection with the present discussion are: (1) that under conditions of high temperature and high humidity the $Ca(OH)_2$ added to $PbHAsO_4$ to prevent the formation of water-soluble arsenic quickly carbonates; and (2) that the $Ca(OH)_2$ after it has carbonated actually *increases* instead of reduces water-soluble arsenic.

In the laboratory studies reported below $CaCO_3$ or $Ca(OH)_2$ was used along with $PbHAsO_4$ at a constant ratio of 6 pounds and 3 pounds respectively in 100 gallons of water. Various amounts of $ZnSO_4 \cdot 7H_2O$ ranging from 6 pounds to ¼ pound in 100 gallons of water were added. The $PbHAsO_4$, $ZnSO_4 \cdot 7H_2O$ and $Ca(OH)_2$ were well-known commercial brands, while the $CaCO_3$ was a "C.P." product. Thruout this experiment ordinary tap water was used, for it was determined at the beginning of the study that the results when tap water was used were about the same as when distilled water was used.

The analyses for water-soluble arsenic were made by the Gutzeit method[22*] and are expressed as the percentage of water-soluble As_2O_5 present in the $PbHAsO_4$ used.

In general the technic employed was as follows:

The materials were weighed, mixed with water, placed in closed containers on a shaking machine, and analyzed for water-soluble arsenic after various periods of shaking. Fifty-cc. samples of some of the mixtures thus prepared were spread in thin films over glass plates. The plates were allowed to dry at room temperature. After they were completely dry they were held in a constant temperature-humidity case[a] in a saturated atmos-

[a]Funds for equipping this case were provided by a grant in aid of research to the junior author by the American Association for the Advancement of Science.

phere at 85° F. After ten days the material was carefully washed off the plates and filtered, and the filtrate was analyzed for water-soluble arsenic. In determining the amount of $ZnSO_4 \cdot 7H_2O$ necessary to reduce water-soluble arsenic in the mixtures, $CaCO_3$ was used instead of $Ca(OH)_2$ in order to eliminate the necessity of carbonating the $Ca(OH)_2$ and also to insure the presence of a uniform carbonate radical as well as a uniform pH value of the mixture.

The results of these studies are shown in Table 1. The data there given represent an average of two completely duplicated series.

Under the conditions of the experiment, ¼ pound of $ZnSO_4 \cdot 7H_2O$ added to mixtures of $PbHAsO_4$ and $CaCO_3$ was as effective as larger amounts in reducing water-soluble arsenic.

TABLE 1.—WATER-SOLUBLE ARSENIC IN SPRAY MIXTURES
(Laboratory studies)

Chemical mixtures[a] (pounds of material in 100 gallons of water)	Held in suspension with constant mixing	Exposure to air on glass plates after mixing	Water-soluble As_2O_5 based on $PbHAsO_4$
	hours	*days*	*perct.*
$PbHAsO_4$ . . . . 3 lbs.	1 1	. . 10	.320 .540
$PbHAsO_4$ . . . . 3 lbs. $Ca(OH)_2$ . . . . 6 lbs.	1 1	. . 10	.110 .930
$PbHAsO_4$ . . . . 3 lbs. $Ca(OH)_2$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . 6 lbs.	1 1	. . 10	.070 Trace
Lead arsenate . . . . 3 lbs. Calcium carbonate . . . . 6 lbs.	1 1	. . 10	1.340 1.680
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . 6 lbs.	1 1	. . 10	.040 .042
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . 4 lbs.	1 2	. . . .	.054 .048
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . 2 lbs.	1 2	. . . .	.049 .048
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . 1 lb.	1 2	. . . .	.051 .048
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . ¾ lb.	1 2	. . . .	.046 .042
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . ½ lb.	1 2	. . . .	.045 .042
$PbHAsO_4$ . . . . 3 lbs. $CaCO_3$ . . . . 6 lbs. $ZnSO_4 \cdot 7H_2O$ . . . . ¼ lb.	1 2	. . . .	.042 .040

[a]The $CaCO_3$ used in this series was a chemically pure product of the Grasselli Chemical Company. The other materials were ordinary commercial products. Tap water was used thruout. The experiment was duplicated, and the results listed above are averages of the two series.

FIELD STUDIES WITH PEACH TREES

Unfortunately the field studies concerning the use of zinc sulfate in peach sprays were practically complete before the laboratory experiment described above was conducted; consequently they were not planned in the light of the foregoing data. One pound in 100 gallons of spray was the smallest amount of $ZnSO_4 \cdot 7H_2O$ used under field conditions, and therefore no information can be given as to whether one-fourth pound would be as effective in the field as it was in the laboratory.

Except for the 1935 studies, the field experiments with the peach were planned for reasons other than to determine the minimum amount of zinc sulfate necessary to eliminate spray injury. Fortunately, however, much of the data secured since 1932 has a direct bearing upon this point. The studies were conducted in four different localities within the state. The spray schedules applied are given on pages 141 to 143. Hale and Elberta trees, all of bearing age, were used.

In examining the data from these experiments (Table 2) it must be borne in mind that comparisons should not be made between separate experiments (that is, experiments in different orchards) nor between results in different years. The orchards varied considerably in soil type and tree vigor, and these variations of course had some effect upon the results. Likewise, the weather, which has a very important bearing upon spray injury, varied widely from orchard to orchard and from year to year. The importance of weather in relation to spray injury is clearly reflected in the data from the Urbana tests for 1934 and 1935. The 1935 season was the most favorable one for spray-injury studies of this nature that has occurred in Illinois for several years. The 1934 season was about average. The varying amounts of lead arsenate used constituted another important source of variation between tests.

Thus, in order to gain an idea of the effects of zinc sulfate in reducing spray injury, comparisons must be made within a given test. Six such comparisons may be made from Table 2. The plots which are comparable are grouped together.

No significant difference in the amount of spray injury on comparable plots in which varying amounts of zinc sulfate were used is apparent from these data (Table 2). One plot in the 1932 Carbondale experiment gave results that were entirely out of line with all other results. This particular plot was on very poor hilly soil where the trees were less vigorous than on other plots, and these conditions may explain the high percentage of injury which occurred.

FOUR ILLINOIS ORCHARDS

Materials applied,[a] zinc-lead-lime	Variety	Number of leaves examined	Leaf injury: Fallen leaves	Leaf injury: Injured, still on tree	Leaf injury: Total leaf injury	Fruit injury: Fruit examined	Fruit injury: Fruit injured[b]	Location and year of experiment, with comments
			perct.	perct.	perct.	number	perct.	
8-8-4	Hale	2 076	6.8	4.7	11.5	.....	...	C. J. Thomas orchard, *Carbondale, 1932*. Trees in excellent vigor. Good, well-drained soil.
4-4-4	Hale	2 990	4.6	2.7	7.3	.....	...	
4-8-4	Hale	2 751	5.3	6.0	11.3	.....	...	
2-4-4	Hale	2 500	6.1	8.0	14.1	.....	...	
1-4-4	Hale	2 561	3.9	7.2	11.1	.....	...	
0-8-4	Hale	2 754	37.6	24.0	61.6	.....	...	
0-4-4	Hale	2 350	34.6	33.9	68.5	.....	...	
0-0-0	Hale	2 491	4.7	.6	5.3	.....	...	
8-8-4	Hale	2 991	14.3	17.7	32.0	.....	...	C. J. Thomas orchard, *Carbondale, 1932*. Trees in moderate vigor. Fair soil, well drained. Land quite hilly. (†This plot was on extra-poor hilly ground.)
4-4-4	Hale	2 851	15.6	27.2	42.8	.....	...	
4-8-4	Hale	2 437	10.0	22.7	32.7	.....	...	
2-4-4	Hale	2 767	16.2	37.3	53.5†	.....	...	
0-0-0	Hale	2 401	5.5	3.1	8.6	.....	...	
8-8-3	Elberta	2 943	8.9	4.0	12.9	1 000	10 66*	E. C. Riechman orchard, *Irvington, 1933*. Trees in poor vigor. Soil well drained and low in fertility. (*Number of drops under 10 trees selected at random; not figured in percent of fruit injured. ††Average of two records taken at different times.)
4-8-3	Elberta	2 651	8.3	6.2	14.5	1 000	14 140	
0-6-3	Elberta	1 986	28.0	22.0	50.0	1 000	53 852	
0-0-0	Elberta	5 856	8.7††	Trace	8.7	1 000	0 43	
8-8-3	Elberta	2 500	9.0	6.0	15.0	.....	...	U. of I. orchard, *Urbana, 1934*. Trees moderate vigor. Good soil well drained.
6-6-3	Elberta	1 979	6.0	8.3	14.3	.....	...	
4-4-3	Elberta	2 056	7.7	9.0	16.7	.....	...	
0-6-3	Elberta	1 489	31.0	21.0	52.0	.....	...	
0-0-0	Elberta	1 389	5.2	0	5.2	.....	...	
8-8-3	Elberta	4 727	9	19	28	3 000	37**	U. of I. orchard, *Urbana, 1935*. Trees moderate vigor. Good soil, well drained. Peach scab in the check plot of Hale was 28 percent; Elberta 5 percent; all other plots free. (**All fruit examined—drops included in percent of injured fruit.)
	Hale	3 942	11	19	30	2 600	32	
6-6-3	Elberta	5 011	8	20	28	4 300	36	
	Hale	3 568	12	19	31	2 100	33	
4-6-3	Elberta	5 160	11	16	27	2 800	34	
	Hale	2 822	16	20	36	400	40	
2-6-3	Elberta	4 936	10	16	26	2 100	35	
	Hale	4 622	17	12	29	500	32	
0-6-3	Elberta	5 894	44	29	73	1 900	65	
	Hale	3 776	56	19	75	600	68	
0-0-0	Elberta	5 114	1	0	1	3 300	1	
	Hale	4 727	2	0	2	1 700	2	
4-4-2	Elberta	3 229	1.6	10	11.6	.....	...	U. of I. orchard, *Olney, 1935*. Trees in excellent vigor. Soil poor, good surface drainage. (The zinc sulfate used in this test was of the formula $ZnSO_4 \cdot 1H_2O$, and in addition to the materials listed 6 pounds of Kolofog were added to each plot.)
3-4-2	Elberta	3 152	1.6	7	8.6	.....	...	
2-4-2	Elberta	3 416	1.7	8	9.7	.....	...	
1-4-2	Elberta	2 859	1.4	8	9.4	.....	...	
0-4-2	Elberta	3 516	32.0	31	63.0	.....	...	
0-0-0	Elberta	3 565	.8	3	3.8	.....	...	

[a]For spray schedules see pages 141 to 144. Formulas indicate pounds of material in 100 gallons of water. Zinc indicates $ZnSO_4 \cdot 7H_2O$, lime $Ca(OH)_2$ and lead $PbHAsO_4$.
[b]Where no figures are given, the fruit was not injured sufficiently by the spray to justify taking records.
†*For explanations represented by these symbols, see right-hand column.

The serious injury in the Urbana plots in 1935 (Table 2) brought out the fact that altho zinc sulfate is very effective in preventing lead arsenate injury to the peach in a normal season, considerable spray injury is likely to result, even tho zinc sulfate is used in the spray mixture, if weather conditions are especially conducive to injury. Frequent light showers, heavy night dews, and high humidity accelerate spray injury.

FIELD STUDIES WITH APPLE TREES

Fruit growers who have observed the beneficial results of zinc sulfate in peach sprays have requested investigations of the possible usefulness of this material in the apple spray program. When in consequence this experiment was undertaken, it was recognized that information on the fungicidal value of zinc sulfate in relation to apple scab (*Venturia inaequalis* (Cke.) Wint.) might be secured while obtaining data on spray injury. And, inasmuch as no information on whether or not the addition of zinc sulfate to lead-lime sprays affects the insecticidal value of the sprays had been secured from the peach spray experiments, it was hoped that such information could be obtained from observations on control of codling moths in this experiment.

The experiment was conducted on Ben Davis apples in the commercial orchard at the University farm, Urbana. There were two trees in each plot except the check, which had one tree only. The studies were planned on a small scale with the intention of enlarging the plots another season if the results the first year justified such action. The spray schedule followed is given on page 144.

Apple scab was first observed in the check plot on May 14. This was the correct time for the calyx spray, which was applied on May 15. Sprays were applied at intervals of ten days to two weeks thereafter. Codling moth injury was first observed in the plots July 4. Both apple scab and codling moth were thus unusually late in appearing. Soon after their appearance, however, heavy infestations were evident in the entire orchard.

Furthermore, cold, wet weather prevailed during the spring, a condition that was ideal for the study of injury from those spray materials which require water to liberate the injurious chemicals. Considering the small size of the plots in this study, therefore, the results were much better and much more conclusive than was expected.

The results on the control of apple scab and codling moth, along with comments on spray injury, are given in Table 3.

Zinc sulfate and lime (Plots 3 and 4) was decidedly inferior to

TABLE 3.—COMMERCIAL ORCHARD SPRAYING RESULTS, URBANA, ILLINOIS, 1935, BEN DAVIS APPLES

Plot[a] No.	Number of fruit examined	Scab injury			Codling moth injury			Comments
		Severe	Light	Total	Entry	Sting	Total	
		perct.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	
1	412	86	4	90	80	2	82	Scab first appeared in check plot 5/14/35. Codling moth first evident 7/4/35. About 95 percent of leaves and fruit fell before harvest. No russet evident.
2	1 000	49	31	80	2	19	21	Heavy defoliation from scab and possible arsenical injury; 12 apples showed russet.
3	1 000	10	25	35	3	19	22	Light defoliation from scab. Trees generally in good condition. Fruit russet severe.
4	1 000	10	25	35	1	26	27	Tree condition as in Plot 3.
5	1 000	1	5	6	2	18	20	Trees generally in good condition. Fruit russet severe.
6	1 000	2	9	11	2	14	16	No russet evident until after copper sprays were applied; moderate at harvest.
7	1 000	5	11	16	7	45	52	Trees generally in good condition. Fruit russet severe. Many late scab infections.

[a]For spray schedules see pages 141 to 144.

copper sulfate and lime (Plot 5) or flotation sulfur (Plot 6) in the control of apple scab. Judging from this limited experiment zinc sulfate cannot be relied upon as a fungicide in an apple schedule.

The effect of zinc sulfate upon arsenical injury to the apple foliage could not be determined in this experiment because of the leaf injury which occurred in Plots 2, 3, and 4 from apple scab. Undoubtedly both zinc sulfate and copper sulfate are efficient in reducing arsenical injury, but zinc sulfate is of no practical value as a fungicide.

At harvest some very good data were secured on spray injury to the fruit. In all plots which received either copper sulfate or zinc sulfate sprays, the fruit was severely russeted. No russet was evident in Plot 6 until the fungicide was changed from flotation sulfur to copper sulfate in anticipation of hot, dry weather. But the weather remained cool and wet, and moderate russet resulted. Generally speaking, it is quite safe to use bordeaux after the application of the second cover spray, but in wet seasons considerable russet may result from later application, as was the case in 1935. This tendency is especially noticeable when russet-susceptible varieties are involved. Apparently zinc sulfate causes as severe russet to susceptible varieties as does copper sulfate.

The effect of zinc sulfate upon the insecticidal value of lead arsenate should not be considered conclusively measured in the limited data presented here; but, such as they are, these results indicate that the addition of zinc sulfate to lead arsenate - lime oil sprays has little effect upon the control of codling moth. Additional data are needed before this point can be definitely settled. The results obtained in this connection from the bordeaux plots were inconsistent.

SUMMARY AND CONCLUSIONS

The data presented in this paper terminate the Illinois study of zinc sulfate as an ingredient in peach and apple sprays. The following conclusions, drawn from seven years of experimental work on this problem, include also the salient points brought out in the former reports of this study.

1. Zinc sulfate has been found especially valuable in reducing peach spray injury resulting from applications of acid lead arsenate and lime. Applications of acid lead arsenate and lime should never be made to the peach as a spray under Illinois field conditions without adding zinc sulfate (Bul. 414[8*]). Hydrated lime added to acid lead arsenate to prevent the formation of water-soluble arsenic quickly carbonates under conditions of high temperature and humidity, and after carbonating actually increases water-soluble arsenic. The carbon

dioxid of the air is the chief source for the carbonation of the lime (Bul. 414[8*]).

2. Small amounts of zinc sulfate appear to be equally as efficient as larger amounts in reducing water-soluble arsenic in peach sprays that consist of acid lead arsenate and hydrated lime or of mixtures of acid lead arsenate and calcium carbonate. One pound in 100 gallons of water, with 3 pounds of acid lead arsenate and 3 pounds of hydrated lime, is apparently sufficient to reduce spray injury effectively under average field conditions.

3. When zinc sulfate was used in apple sprays at concentrations of 8 pounds to 100 gallons of water with acid lead arsenate and lime, severe russet resulted to Ben Davis apples. Russet also resulted from 4- to 5-pound applications of copper sulfate in bordeaux. The influence on apples of small amounts of zinc sulfate was not determined.

4. Studies of the effect of zinc sulfate on the insecticidal value of lead arsenate and lime, conducted over a period of seven years, have not been conclusive. The limited data secured on codling moth control indicate that zinc sulfate has no marked influence in so far as this insect is concerned. The fact that oil was added to the sprays in this test may have had a bearing upon the results obtained.

5. On the basis of these studies zinc sulfate is not recommended as a fungicide in peach or apple sprays. In laboratory studies it proved much more toxic to apple scab (*Venturia inaequalis* (Cke.) Wint.) than to brown rot (*Sclerotinia fructicola* (Wint.) Rehm.). Under field conditions, however, it proved only 65 percent effective in the control of apple scab. No significant data have been secured from field studies on zinc sulfate in the control of brown rot, but laboratory tests indicate very little value for zinc sulfate in this capacity. Data presented in Bul. 414[8*] indicate that zinc sulfate does not improve the fungicidal value of lead arsenate and lime in the control of peach scab (*Cladosporium carpophilum* Thum). Two or three lead arsenate-lime sprays for the control of curculio with or without zinc sulfate are usually sufficient to control peach scab in Illinois.

6. According to the results of the Illinois study, zinc sulfate is not an effective bactericide for the control of bacterial spot (*Phytomonas pruni* (E.F.S.) Bergey et al) on peach and therefore is not recommended for use in this connection (Bul. 414[8*]).

7. Zinc sulfate has not been observed to impart any "stimulating effect" to the peach under Illinois field conditions, altho certain physiological diseases have been corrected by it in other parts of the country. Physiological studies indicate that soluble zinc is necessary

for the proper development of many plants, including the peach (Bul. 414[8*]).

LITERATURE CITED

1. ADAMS, J. F. Peach defoliation in relation to the zinc-lime spray in combination with certain sulphur sprays. Del. State Bd. Agr. Bul. **22**, 113-120. 1932.
2. ANDERSON, H. W. Problems on spray injury to the peach. Ill. State Hort. Soc. Trans. **65**, 454-468. 1931.
3. ——— and THORNBERRY, H. H. Peach spraying experiments for brown rot and bacterial spot control. Ill. State Hort. Soc. Trans. **63**, 129-137. 1929.
4. HAENSLER, C. M., and MARTIN, W. H. Arsenical injury of the peach. Phytopathology **15**, 321-331. 1925.
5. HURT, R. H. Zinc lime spray and its importance as a peach spray and tar oil distillates as dormant spray materials for fruit trees. Va. State Hort. Soc. Rpt. **20**, 94-104. 1932.
6. ——— Zinc and copper spray materials for peaches and apples. Va. State Hort. Soc. Rpt. **21**, 55-64. 1933.
7. KADOW, K. J. Zinc sulfate as a fungicide and bactericide, together with its effect on peach growth and on peach spray injury. Ill. State Hort. Soc. Trans. **68**, 240-257. 1934.
8. ——— and ANDERSON, H. W. The role of zinc sulfate in peach sprays. Ill. Agr. Exp. Sta. Bul. 414. 1935.
9. ——— ———. Zinc sulfate in peach and apple sprays. Ill. State Hort. Soc. Trans. **69**, 246-253. 1935.
10. POOLE, R. F. A study of the control of the bacterial spot of peaches and the nearly similar canker and spot caused by arsenate injury and their control. N.C. Agr. Exp. Sta. Ann. Rpt. 54, 76-79, 1931.
11. ——— Arsenical injury of the peach and some results of studies on its control. Amer. Soc. Hort. Sci. Proc. **29**, 42-44. 1932.
12. ROBERTS, J. W., and PIERCE, LESLIE. A promising spray for the control of peach bacterial spot. Phytopathology **19**, 106-107. 1929.
13. ——— ——— Controlling peach bacterial spot. Hoosier Hort. **11**, 6-12. 1929.
14. ——— ——— Control of peach bacterial spot. Md. Agr. Soc. Rpt. **13** (1928), 153-159. 1929.
15. ——— ——— Control of peach bacterial spot. Peninsula Hort. Soc. (Del.) Trans. **42**, 102-106. 1929.
16. ——— ——— Zinc-lime: A fungicide for the peach. Phytopathology **22**, 415-427. 1932.
17. ——— ——— and DUNEGAN, J. C. Control of peach bacterial spot. Ill. State Hort. Soc. Trans. **63**, 423-426. 1929.
18. ——— ——— ——— Control of peach bacterial spot. Ga. State Hort. Soc. Proc. **53**, 32-35. 1929.
19. ——— ——— ——— Control of peach bacterial spot. Md. Agr. Soc. Rpt. **14** (1929), 221-226. 1930.
20. ——— ——— ——— Control of peach bacterial spot. Amer. Fruit Grower Mag. **50**, 10-11. 1930.
21. RUDOLPH, B. A. Bacteriosis (blight) of the English walnut in California and its control. Cal. Agr. Exp. Sta. Bul. 564. 1933.
22. SKINNER, W. W. *et al.* Official and tentative methods of analysis of the association of official agriculture chemists, pp. 306-309 3d ed. Assoc. Off. Agr. Chem. Washington, D.C. 1930.

SPRAY SCHEDULE No. 1.—PEACH EXPERIMENTS AT C. J. THOMAS ORCHARD, CARBONDALE, ILLINOIS, 1932[a]

Plots	Materials in early-season sprays	Early-season sprays applied						Plot	Late-season sprays		
		Shuck	2d	3d	4th	5th	6th		Materials	1st	2d
1, 13	Zinc-lime-lead 8-8-4-100	x	x	x	x	...	...	1	Kolofog 10-100	x	x
	Zinc-lime 8-8-100	...	...	...	...	x	x				
2, 14	Zinc-lime-lead 4-4-4-100	x	x	x	x	...	...	2	Dritomic 6-100	x	x
	Zinc-lime 4-4-100	...	...	...	...	x	x				
3, 15	Zinc-lime-lead 4-8-4-100	x	x	x	x	...	...	3	Flotation sulfur paste 12-100	x	x
	Zinc-lime 4-8-100	...	...	...	...	x	x				
4, 16	Zinc-lime-lead 2-4-4-100	x	x	x	x	...	...	4	Flotation sulfur dry 6-100	x	x
	Zinc-lime 2-4-100	...	...	...	...	x	x				
5	Zinc-lime-lead 1-4-4-100	x	x	x	x	...	...	5	Sulfur dust, 300-mesh	80%	80%
	Zinc-lime 1-4-100	...	...	...	...	x	x		Lime	20%	20%
6, 9	Lime-lead 16-4-100	x	x	x	x	...	...	6	Sulfur dust, 300-mesh	80%	80%
									Lime	15%[b]	15%[b]
									Oil (by weight)	5%	5%
								9	Flotation sulfur dust	25%	25%
									300-mesh sulfur	55%	55%
									Lime	20%	20%
7, 18	Lime-lead 8-4-100	x	x	x	x	...	...	7	Flotation sulfur dust	80%	80%
									Lime	20%	20%
8	Lime-lead 4-4-100	x	x	x	x	...	...	8	Flotation sulfur dust	45%	45%
									300-mesh sulfur	35%	35%
									Lime	20%	20%
17	Lead 4-100	x	x	x	x	...	...				
17a	Absolute check	...	...	...	...	...	...	17a	No treatment	....	....
10,19	Zinc-lime 8-8-100	x	x	x	x	x	x	10	Flotation sulfur dust	25%	25%
									300-mesh sulfur	55%	55%
									Lime	15%[b]	15%[b]
									Oil (by weight)	5%	5%
Check 1	Absolute check	...	...	...	...	...	...	Check 1		....	....
Check 2	Zinc-lime-lead 8-8-3-100	x	x	x	x	...	...	Check 2		....	....
11	Lead-lime 3-6-100	x	x	x	x	...	...				
	Flotation paste 12-100	...	x	x	x	...	...				

[a]Cooperative experiment by Department of Horticulture and Illinois State Natural History Survey. Sprays applied at two-week intervals beginning April 25 to 27, 1932. Fungicidal sprays applied three weeks and one week before harvest. [b]In Bul. 414 this figure was erroneously stated as 20 percent.

SPRAY SCHEDULE NO. 2.—PEACH EXPERIMENTS AT E. C. RIECHMAN ORCHARD, IRVINGTON, ILLINOIS, 1933[a]

Plot	Spray materials used	Early-season sprays applied				
		Shuck	2d	3d	4th	5th
1.........	Absolute check—no sprays or dusts	..	..	..	..	..
2.........	Lead-lime 3-6-100..............	x	x	x	x	x
3.........	Lead-lime-zinc 3-8-8-100.........	x	x	x	x	x
4.........	Lead-lime-zinc 3-8-4-100.........	x	x	x	x	..

[a]Sprays were applied at intervals of about two weeks. Orchard rather low in vigor, with general infections of peach scab and bacterial spot. All trees in the experiment were Elbertas.

SPRAY SCHEDULE NO. 3.—PEACH EXPERIMENTS AT UNIVERSITY ORCHARD, URBANA, ILLINOIS, 1934[a]

Plot	Spray materials used	Early-season sprays applied				
		Shuck	2d	3d	4th	5th
1.........	Absolute check—no sprays or dusts	..	..	..	..	..
2.........	Lead-lime 3-6-100..............	x	x	x	x	..
3.........	Lead-lime-zinc 3-4-4-100.........	x	x	x	x	..
4.........	Lead-lime-zinc 3-6-6-100.........	x	x	x	x	..
5.........	Lead-lime-zinc 3-8-8-100.........	x	x	x	x	..

[a]Sprays were applied at intervals of two weeks. Orchard in moderate vigor. All trees in the experiment were Elbertas.

SPRAY SCHEDULE No. 4.—PEACH EXPERIMENTS AT UNIVERSITY ORCHARD, URBANA, ILLINOIS, 1935[a]

Plot	Spray materials used	Early-season sprays applied				
		Shuck	2d	3d	4th	5th
1.........	Absolute check—no sprays or dusts	..	..	..	..	..
2.........	Lead-lime 3-6-100..............	..	x	x	x	..
3.........	Lead-lime-zinc 3-6-2-100.........	..	x	x	x	..
4.........	Lead-lime-zinc 3-6-4-100.........	..	x	x	x	..
5.........	Lead-lime-zinc 3-6-6-100.........	..	x	x	x	..
6.........	Lead-lime-zinc 3-8-8-100.........	..	x	x	x	..

[a]Sprays were applied at intervals of about two weeks. Orchard in moderate vigor. Trees in the experiment were Elberta and Hale varieties.

SPRAY SCHEDULE No. 5.—PEACH EXPERIMENTS AT UNIVERSITY ORCHARD, OLNEY, ILLINOIS, 1935[a]

Plot	Spray materials used	Early-season sprays applied				
		Shuck	2d	3d	4th	5th
1.........	Absolute check—no sprays or dusts	..	..	..	..	..
2.........	Lead-lime 2-4-100 Kolofog 6-100	..	x	x	x	..
3.........	Lead-lime-zinc 2-4-1-100 Kolofog 6-100	..	x	x	x	..
4.........	Lead-lime-zinc 2-4-2-100 Kolofog 6-100	..	x	x	x	..
5.........	Lead-lime-zinc 2-4-3-100 Kolofog 6-100	..	x	x	x	..
6.........	Lead-lime-zinc 2-4-4-100 Kolofog 6-100	..	x	x	x	.

[a]Sprays were applied at intervals of about two weeks. Trees in excellent vigor. All trees in this experiment were Elberta. The zinc sulfate used in this study was of the formula $ZnSO_4 \cdot 1H_2O$ instead of the $ZnSO_4 \cdot 7H_2O$ used in all the other spray tests.

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SPRAY SCHEDULE No. 6.—APPLE EXPERIMENTS AT UNIVERSITY COMMERCIAL ORCHARD, URBANA, ILLINOIS, 1935, BEN DAVIS APPLES
(The figures indicate pounds of material in 100 gallons of water, except the oil, which was measured according to volume)[a]

Plot No	Prebloom (4/19/35)	Calyx (5/15/35)	1st cover (5/24/35)	2d cover (6/13/35)	3d cover (6/27/35)	4th cover (7/6/35)	5th cover (7/26/35)	6th cover (8/14/35)
1	Check plot—no sprays or dusts after dormant season	....	....	....	....	....	....	....
2	Lime........ 8	Lead........ 3 Lime........ 8	Lime........ 8	Lime........ 8	Lead........ 3 Lime........ 8	Lead........ 3 Lime........ 8	Lead....... 3 Lime....... 8 Oil........ ¾%	Lead....... 3 Lime....... 8 Oil........ ¾%
3	Lime........ 8 Zinc........ 8	Lead........ 3 Lime........ 8 Zinc........ 8	Lime........ 8 Zinc........ 8	Lime........ 8 Zinc........ 8	Lead........ 3 Lime........ 8 Zinc........ 8	Lead........ 3 Lime........ 8 Zinc........ 8	Lead....... 3 Lime....... 8 Zinc....... 8 Oil........ ¾%	Lead....... 3 Lime....... 8 Zinc....... 8 Oil........ ¾%
4	Lime........ 8 Zinc........ 8	Lead........ 6 Lime........ 8 Zinc........ 8	Lime........ 8 Zinc........ 8	Lime........ 8 Zinc........ 8	Lead........ 6 Lime........ 8 Zinc........ 8	Lead........ 6 Lime........ 8 Zinc........ 8	Lead....... 6 Lime....... 8 Zinc....... 8 Oil........ ¾%	Lead....... 6 Lime....... 8 Zinc....... 8 Oil........ ¾%
5	Lime........ 8 Copper...... 6	Lead........ 3 Lime........ 8 Copper...... 6	Lime........ 8 Copper...... 6	Lime........ 8 Copper...... 5	Lead........ 3 Lime........ 8 Copper...... 5	Lead........ 3 Lime........ 8 Copper...... 4	Lead....... 3 Lime....... 8 Copper..... 4 Oil........ ¾%	Lead....... 3 Lime....... 8 Copper..... 4 Oil........ ¾%
6	Flotation sulfur......10	Lead........ 3 Lime........ 8 Sulfur....... 8	Flotation sulfur......10	Flotation sulfur......10	Lead........ 3 Lime........ 8 Sulfur....... 6	Lead........ 3 Lime........ 8 Copper...... 4	Lead....... 3 Lime....... 8 Copper..... 4 Oil........ ¾%	Lead....... 3 Lime....... 8 Oil........ ¾%
7	Lime........ 8 Copper...... 6	Lead........ 3 Lime........ 8 Copper...... 6	Lime........ 8 Copper...... 6	Lime........ 8 Copper...... 5	Lead........ 3 Lime........ 8 Copper...... 5	Lead........ 3 Lime........ 8 Copper...... 4	Lead....... 3 Ortho K spreader... ½ Oil........ ¾%	Lead....... 3 Ortho K spreader... ½ Oil........ ¾%

[a]Ortho K summer oil was used in the fifth and sixth cover sprays only. The chemicals used were hydrated lime, granulated zinc sulfate ($ZnSO_4 \cdot 7H_2O$), flotation sulfur, acid lead arsenate ($PbHAsO_4$) and powdered copper sulfate ($CuSO_4 \cdot 5H_2O$).